

XXXIX. *An Account of the Gymnotus Electricus.*

By John Hunter, F. R. S.

Redde, May 11, 1775. **T**O MR. WALSH, the first discoverer of animal electricity, the learned will be indebted for whatever the following pages may contain, either curious or useful. The specimen of the animal which they describe was procured by that Gentleman, and at his request this dissection was performed, and this account of it is communicated.

This fish, on the first view, appears very much like an eel, from which resemblance it has most probably got its name; but it has none of the specific properties of that fish. This animal may be considered, both anatomically and physiologically, as divided into two parts; *viz.* the common animal part; and a part which is superadded, *viz.* the *peculiar organ*. I shall at present consider it only with respect to the last; as the first explains nothing relating to the other, nor any thing relating to the animal oeconomy of fish in general. The first, or common animal part, is so contrived as to exceed what was necessary for itself, in order to give situation, nourishment, and most probably the peculiar property to the second. The last part, or peculiar organ, has an immediate connexion with the first; the body affording it a situation; the heart, nourishment; and the brain, nerves and probably its peculiar powers. For the first of these purposes, the body is extended out in length, being much longer

G g g 3 than

than would be sufficient for what may be called its progressive motion. For the real body, or that part where the *viscera* and parts of generation lye, is situated, with respect to the head, as in other fish, and is extremely short; so that, according to the ordinary proportions, this should be a very short fish. Its great length, therefore, seems chiefly intended to afford a surface for the support of the peculiar organ: however, the tail-part is likewise adapted to the progressive motion of the whole, and to preserve the specific gravity; for the spine, *medulla spinalis*, muscles, fin, and air-bladder, are continued through its whole length. Besides which parts, there is a membrane passing from the spine to that fin which runs along the belly or lower edge of the animal. This membrane is broad at the end next to the head, terminating in a point at the tail. It is a support for the abdominal fin, gives a greater surface of support for the organ, and makes a partition between the organs of the two opposite sides.

THE ORGANS.

The organs which produce the peculiar effect of this fish, constitute nearly one-half of that part of the flesh in which they are placed, and perhaps make more than one-third of the whole animal. There are two pair of these organs, a larger, and a smaller; one being placed on each side. The large pair occupy the whole lower or anterior, and also the lateral part of the body, making the thickness of the fore or lower parts of the animal, and run almost through its whole length; *viz.* from the *abdomen* to near the end of the tail^(a). It is broadest on

(a) Vide pl. II. fig. 1. KKK:

the sides of the fish at the anterior end, where it incloses more of the lateral parts of the body, becomes narrower towards the end of the tail, occupying less and less of the sides of the animal, till at last it ends almost in a point.

These two organs are separated from one another at the upper part, by the muscles of the back, which keep their posterior or upper edges at a considerable distance from one another^(b); below that, and towards the middle, they are separated by the air-bag^(c); and at their lower parts they are separated by the middle partition^(d).

They begin forwards, by a pretty regular edge, almost at right angles with the longitudinal axis of the body, situated on the lower and lateral parts of the *abdomen*.

Their upper edge is a pretty straight line, with small indentations made by the nerves and blood vessels, which pass round it to the skin. At the anterior end they go as far towards the back as the middle line of the animal; but in their approach towards the tail they gradually leave that line, coming nearer to the lower surface of the animal.

The general shape of the organ, on an external or side view, is broad at the end next to the head of the animal, becoming gradually narrower towards the tail, and ending there almost in a point.

The other surfaces of the organ are fitted to the shape of the parts with which they come in contact; therefore on the upper and inner surface it is hollowed, to receive the muscles of the back^(e). There is also a longitudinal depression on its lower edge, where a substance

(b) Pl. IV. cccc. (c) Pl. IV. d. (d) Pl. IV. k. (e) Pl. IV.

lies, which divides it from the small organ, and which gives a kind of fixed point for the lateral muscles of the fin (*f*). Its most internal surface is a plane adapted to the partition which divides the two organs from one another (*g*). The edge next to the muscles of the back is very thin, but the organ becomes thicker and thicker towards its middle, where it approaches the center of the animal. It becomes thinner again, towards the lower surface or belly; but that edge is not so thin as the other (*h*). Its union with the parts to which it is attached is in general by a loose, but pretty strong, cellular membrane; except at the partition, to which it is joined so close as to be almost inseparable.

The small organ lies along the lower edge of the animal, nearly to the same extent as the other (*i*). Its situation is marked externally by the muscles which move the fin under which it lies. Its anterior end begins nearly in the same line with the large organ, and just where the fin begins. It terminates almost insensibly near the end of the tail, where the large organ also terminates. It is of a triangular figure, adapting itself to the part in which it lies (*k*). Its anterior end is the narrowest part; towards the tail it becomes broader; in the middle of the organ it is thickest; and from thence becomes gradually thinner to the tail, where it is very thin. The two small organs are separated from one another by the middle muscles, and by the bones upon which

(*f*) Pl. IV. (*g*) Pl. IV. (*h*) Pl. IV. (*i*) Pl. II. fig. 1. LLL.

(*k*) Pl. IV. II.

the bones of the fins are articulated ^(l). The large and the small organ on each side, are separated from one another by a membrane, the inner edge of which is attached to the middle partition, and its outer edge is lost on the skin of the animal ^(m). To expose the large organ to view, nothing more is necessary than to remove the skin, which adheres to it by a loose cellular membrane. But to expose the small organ, it is necessary to remove the long row of small muscles which move the fin

OF THE STRUCTURE OF THESE ORGANS.

The structure is extremely simple and regular, consisting of two parts; *viz.* flat partitions or *septa*, and cross divisions between them. The outer edge of these *septa* appear externally in parallel lines nearly in the direction of the longitudinal axis of the body ⁽ⁿ⁾. These *septa* are thin membranes, placed nearly parallel to one another. Their lengths are nearly in the direction of the long axis, and their breadth is nearly the semi-diameter of the body of the animal ^(o). They are of different lengths, some being as long as the whole organ. I shall describe them as beginning principally at the anterior end of the organ, although a few begin along the upper edge; and the whole, passing towards the tail, gradually terminate on the lower surface of the organ; the lowermost at their origin terminating soonest. Their breadths differ in different parts of the organ. They are in general broadest near the anterior end, answering to the thickest part of

(l) Pl. III. E. (m) Pl. III. P. (n) Pl. II. ККК. (o) Pl. IV. HH.

the organ, and become gradually narrower towards the tail; however, they are very narrow at their beginnings or anterior ends. Those nearest to the muscles of the back are the broadest, owing to their curved or oblique situation upon these muscles, and grow gradually narrower towards the lower part, which is in a great measure owing to their becoming more transverse, and also to the organ becoming thinner at that place^(p). They have an outer and an inner edge. The outer is attached to the skin of the animal, to the lateral muscles of the fin, and to the membrane which divides the great organ from the small; and the whole of their inner edges are fixed to the middle partition formerly described, also to the air-bladder, and three or four terminate on that surface which inclose the muscles of the back^(q). These *septa* are at the greatest distance from one another at their exterior edges near the skin, to which they are united; and as they pass from the skin towards their inner attachments they approach one another^(r). Sometimes we find two uniting into one. On that side next to the muscles of the back, they are hollow from edge to edge, answering to the shape of those muscles; but become less and less so towards the middle of the organ; and from that towards the lower part of the organ, they become curved in the other direction^(s). At the anterior part of the large organ, where it is nearly of an equal breadth, they run pretty parallel to one another, and also pretty straight;

(p) Pl. IV. where the different breadths are seen in one view.

(q) Pl. IV.

(r) Pl. IV.

(s) Pl. IV.

but where the organ becomes narrower, it may be observed in some places, that two join or unite into one; especially where a nerve passes across. The termination of this organ at the tail is so very small that I could not determine, whether it consisted of one *septa* or more. The distances between these *septa* will differ in fishes of different sizes. In a fish of two feet four inches in length, I found them $\frac{1}{27}$ of an inch distant from one another; and the breadth of the whole organ, at the broadest part, about an inch and a quarter, in which space were thirty-four *septa*. The small organ has the same kind of *septa*, in length passing from end to end of the organ, and in breadth passing quite across; they run somewhat serpentine, not exactly in straight lines⁽¹⁾. Their outer edges terminate on the outer surface of the organ, which is in contact with the inner surface of the external muscle of the fin, and their inner edges are in contact with the centre-muscles. They differ very much in breadth from one another; the broadest being equal to one side of the triangle, and the narrowest scarcely broader than the point or edge, They are pretty nearly at equal distances from one another; but much nearer than those of the large organ, being only about $\frac{1}{36}$ th part of an inch asunder: but they are at a greater distance from one another towards the tail, in proportion to the increase of breadth of the organ. The organ is about half an inch in breadth, and has fourteen *septa*. These *septa*, in both organs, are very

(1) Pl. II. 111.

tender in consistence, being easily torn. They appear to answer the same purpose with the columns in the *torpedo*, making walls or butments for the sub-divisions, and are to be considered as making so many distinct organs. These *septa* are intersected transversely by very thin plates or membranes, whose breadth is the distance between any two *septa*, and therefore of different breadths in different parts; broadest at that edge which is next to the skin; narrowest at that next to the center of the body, or to the middle partition which divides the two organs from one another. Their lengths are equal to the breadths of the *septa*, between which they are situated. There is a regular series of them continued from one end of any two *septa* to the other. They appear to be so close as even to touch. In an inch in length there are about 240, which multiplies the surface in the whole to a vast extent.

O F T H E N E R V E S.

The nerves in this animal may be divided into two kinds; the first, appropriated to the general purposes of life; the second, for the management of this peculiar function, and very probably for its existence. They arise in general from the brain and *medulla spinalis*, as in other fish; but those from the *medulla* are much larger than in fish of equal size, and larger than is necessary for the common operations of life. The nerve which arises from the brain, and passes down the whole length of the animal (which I believe exists in all fish) is larger
in

in this than in others of the same size, and passes nearer to the spine^(u). In the common eel it runs in the muscles of the back, about midway between the skin and spine. In the cod it passes immediately under the skin. From its being larger in this fish than in others of the same size, one might suspect, that it was intended for supplying the organ in some degree; but this seems not to be the case, as I was not able to trace any nerves going from it to join those from the *medulla spinalis*, which run to the organ. This nerve is as singular an appearance as any in this class of animals; for surely it must appear extraordinary, that a nerve should arise from the brain to be lost in common parts, while there is a *medulla spinalis* giving nerves to the same parts. It must still remain one of the inexplicable circumstances of the nervous system. The organ is supplied with nerves from the *medulla spinalis* from which they come out in pairs between all the *vertebræ* of the spine^(*). In their passage from the spine they give nerves to the muscles of the back, &c. They bend forwards and outwards upon the spine, between it and the muscles, and send out small nerves to the external surface, which join the skin near to the lateral lines. These ramify upon the skin, but are principally bent forwards between it and the organ, into which they send small branches as they pass along. They seem to be lost in these two parts. The trunks get upon the air-bladder, or rather dip between it and the muscles of the back, and continuing

(u) Pl. III. T.

(*) Pl. III. s.

their

their course forwards upon that bag, they dip in between it and the organ, where they divide into smaller branches; then they get upon the middle partition, on which they continue to divide into still smaller branches; after which they pass on, and get upon the small bones and muscles, which are the bases for the under fin, and at last they are lost on that fin. After having got between the organ and the above mentioned parts, they are constantly sending small nerves into the organs; first into the great organ, and then into the small one; also into the muscles, of the fin, and at last into the fin itself. These branches, which are sent into the organ as the trunk passes along, are so small, that I could not trace their ramifications in the organs. In this fish, as well as in the *torpedo*, the nerves which supply the organ are much larger than those bestowed on any other part for the purposes of sensation and action; but it appears to me, that the organ of the *torpedo* is supplied with much the largest proportion. If all the nerves which go to it were united together, they would make a vastly greater chord, than all those which go to the organ of this eel. Perhaps when experiments have been made upon this fish, equally accurate with those made upon the *torpedo*, the reason for this difference may be assigned.

B L O O D V E S S E L S .

How far this organ is vascular, I cannot positively determine; but from the quantities of small arteries going to it, I am inclined to believe, that it is not deficient in vessels.

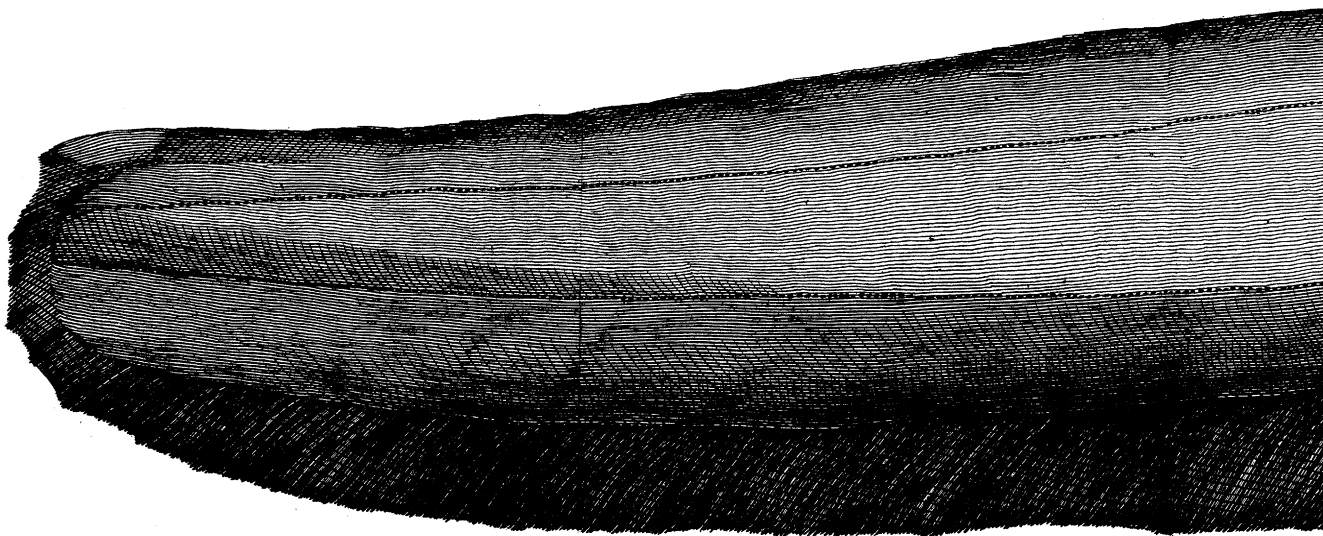
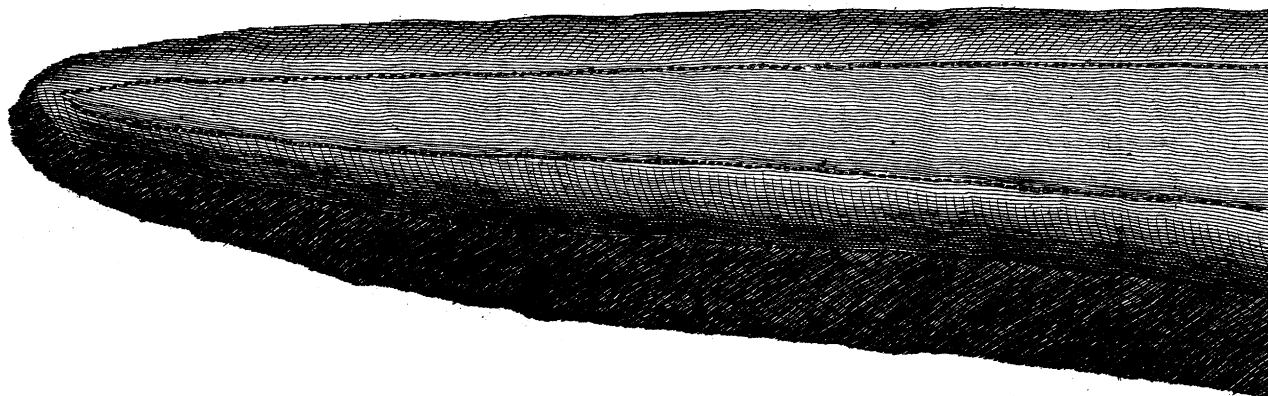


Fig 1

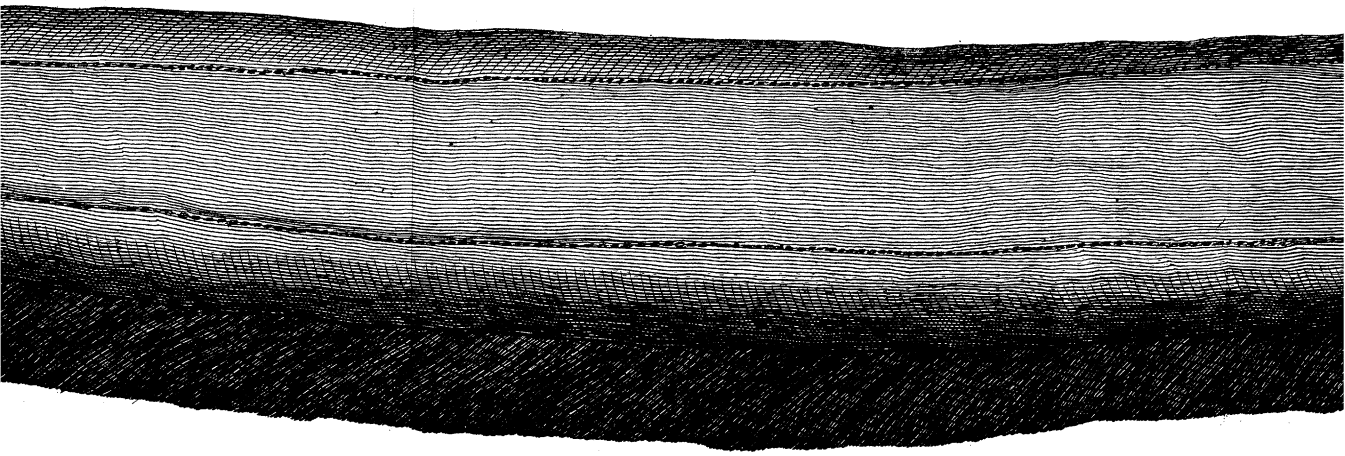
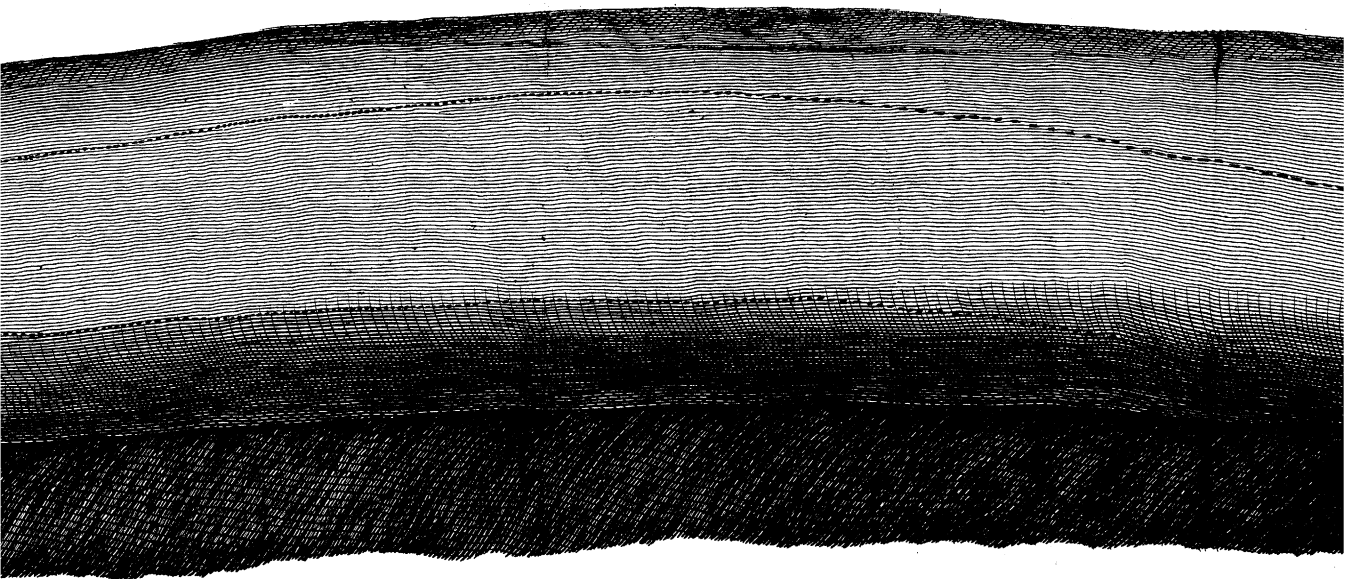
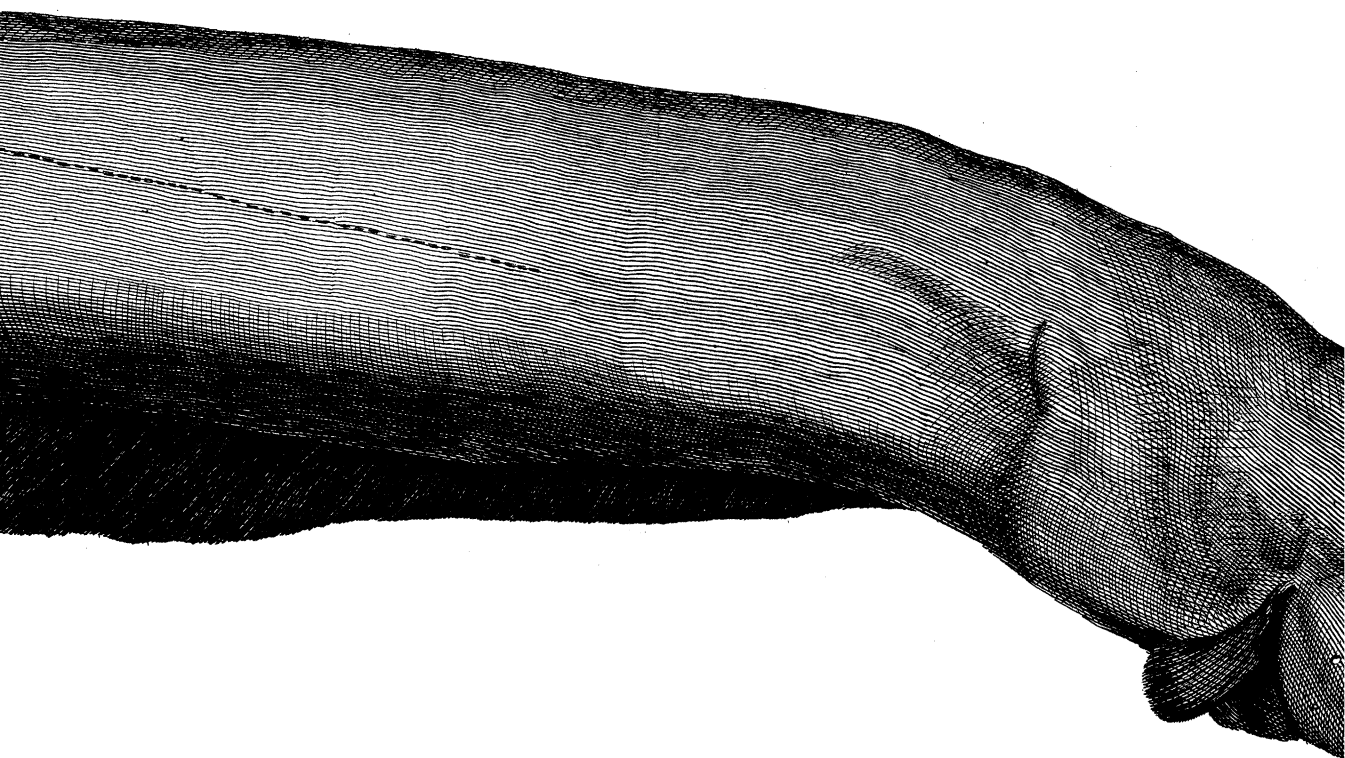
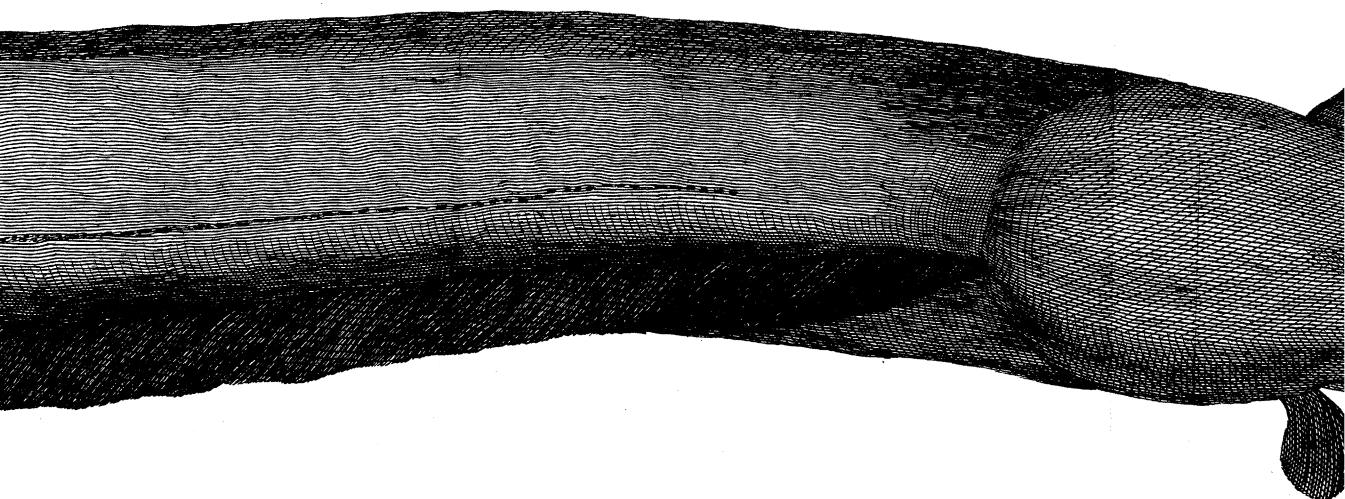
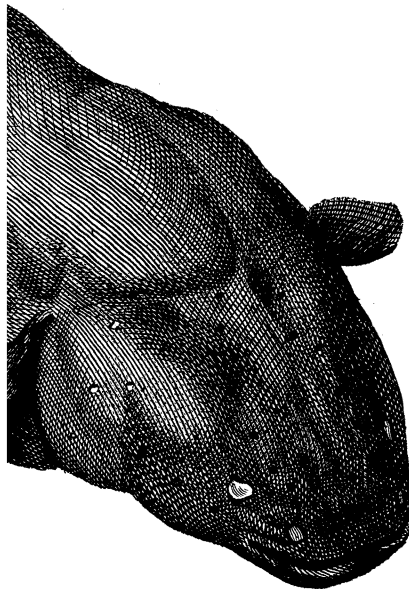
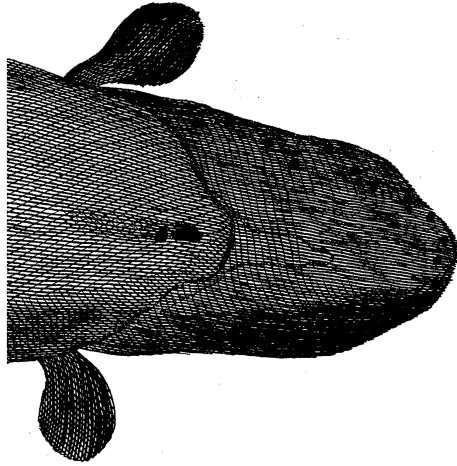


Fig 2







James Roberts Sculp



vessels. The arteries arise from the large artery which passes down the spine; they go off in small branches like the *intercostals* in the human subject, pass round the air-bladder, and get upon the partition together with the nerves, and distribute their branches in the same manner. The veins take the same course backwards, and enter the large vein which runs parallel with the artery.

P L A T E I. F I G. I.

Shews the whole animal of the full size. It lies on one side; which posture exposes the whole of the under fin. The head is twisted, to shew its upper part, on which are seen the eyes, &c.

F I G. II.

Shews the animal lying in the same position, but the head is twisted in the contrary direction, so as to expose its under surface. Between the two fins, and before the beginning of the under fin, is the cavity of the belly of the fish; at the anterior part of which cavity is the *anus*.

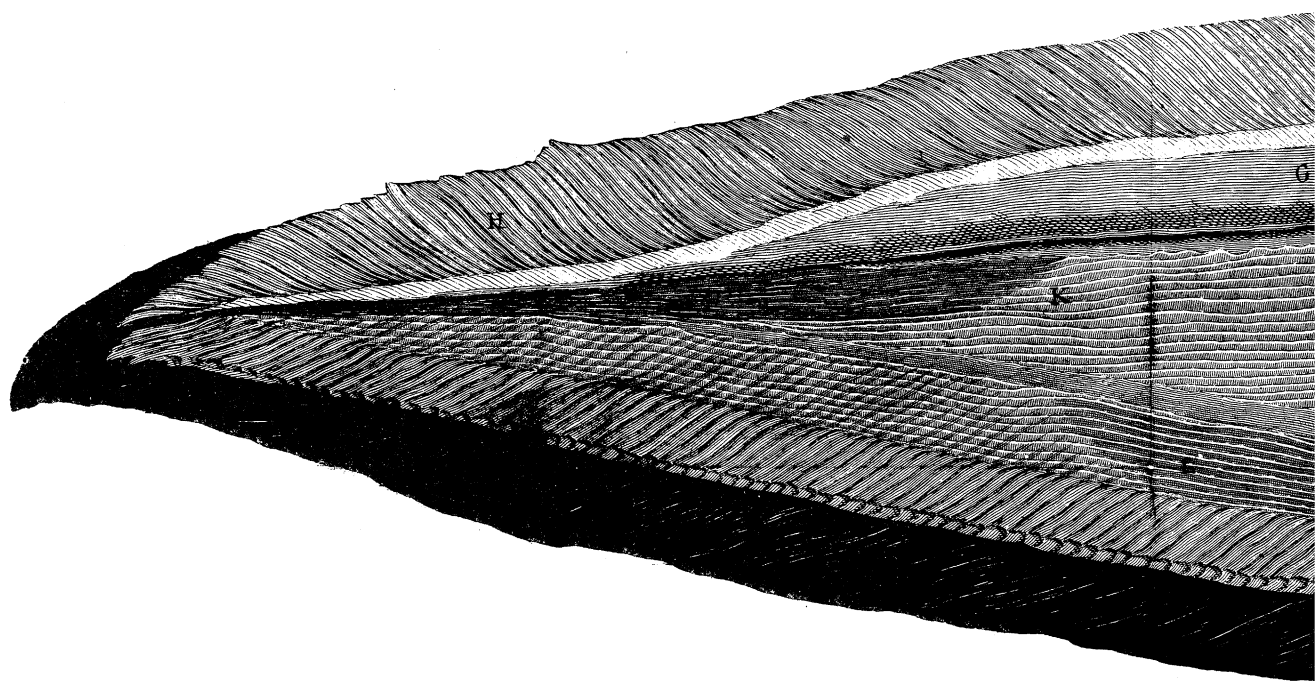
P L A T E II. F I G. I.

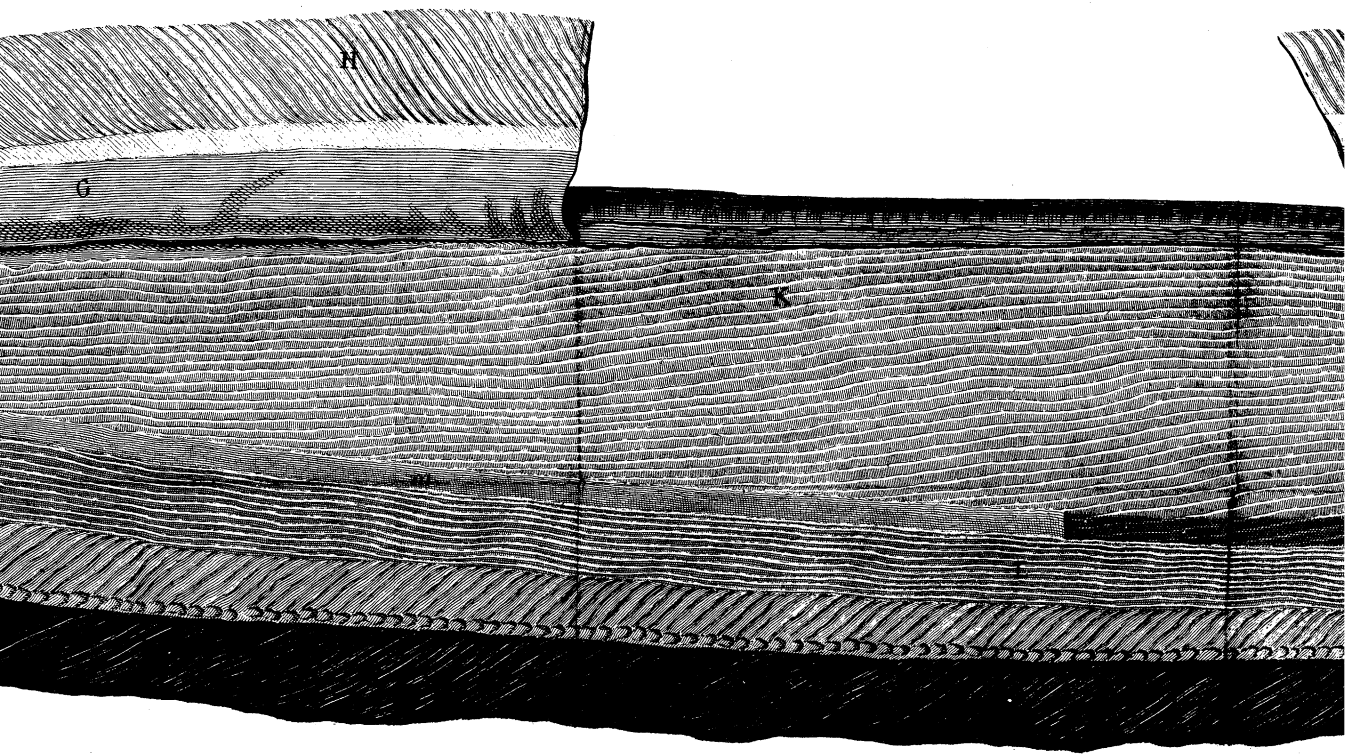
Exhibits the whole of the two organs on each side, the skin being removed as far as these organs extend. A. The lower surface of the head of the animal. B. The cavity of the belly. c. The *anus*. D. The fin. E. The back of the fish where the skin has not been removed. FF. The fin which runs along the lower edge

edge of the fish. **GGG.** The skin turned back. **HHH.** The lateral muscles of the above fin removed and carried back with the skin, to expose the small organ. **I.** Part of the muscle left in its place. **KKK.** The large organ. **LLL.** The small organ. **MMMM.** The substance which divides the large organ from the small. **N.** At this place the above substance is removed.

P L A T E III. F I G. IV.

A section of the whole thickness of the fish near the upper part, a little magnified. The skin is removed as far back as the posterior edge of the organ, and the other parts immediately belonging to it, such as the *medulla spinalis*. There are several pieces or sections taken out of the organ, which expose every thing that has any relation to it. At the upper and lower ends of the figure, **FF**, the organ is entire, the skin only being removed. **AA.** The body of the animal near the back, covered by the skin. **BB.** The belly-fin, covered also by the skin. **c.** Part of the skin removed from the organ, and turned back. **DD.** The muscles which move the fin laterally, and which immediately cover the small organ. **E.** The middle muscles of the fin, which lay immediately between the two small organs. **FF.** The outer surface of the large organ, as it appears when the skin is removed. **G.** The small organ, as it appears when the lateral muscles are removed. **HH.** The cut ends of the muscles of the back, which have been removed to expose the deeper seated





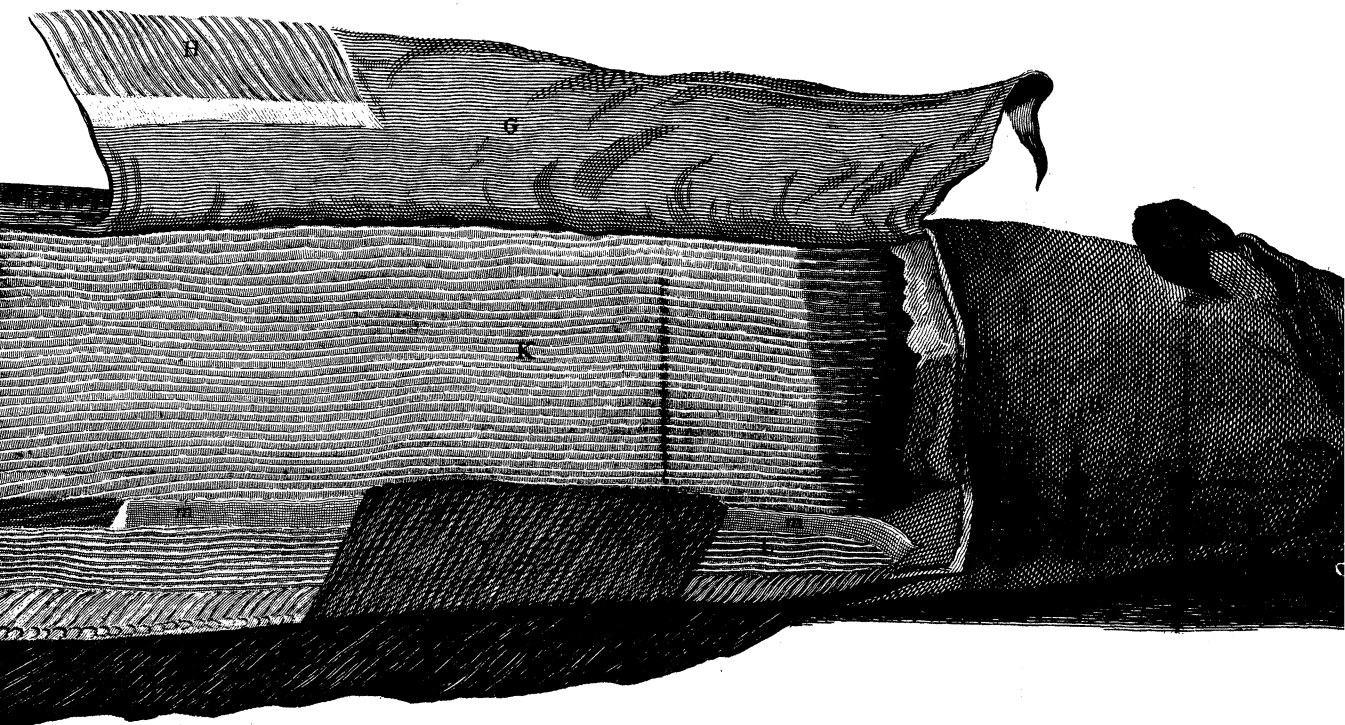
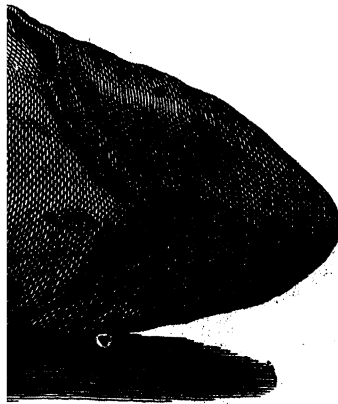


Plate 2



James Roberts sculp

feated parts. II. The cut ends of the large organ, part of which has also been removed, to expose the deeper seated parts. K. The cut end of the small organ. L. A part of the large organ, the rest having been removed. M. The cut end of the above section. N. A section of the small organ. OO. The middle partition which divides the two large organs. P. A fatty membrane, which divides the large organ from the small. Q. The air-bladder. R. The nerves going to the organ. S. The *medulla spinalis*. T. The singular nerve.

P L A T E IV. F I G. V.

A transverse section of the fish, exposing at one view, all the parts of which it is composed. A. The external surface of the side of the fish. B. The under fin. CCCC. The cut ends of the muscles of the back. D. The cavity of the air-bladder. E. The body of the spine. F. The *medulla spinalis*. G. The large artery and vein. HH. The cut ends of the two large organs. II. The cut ends of the two small organs, K. The partition between the organs.

Plate 4

Fig 5

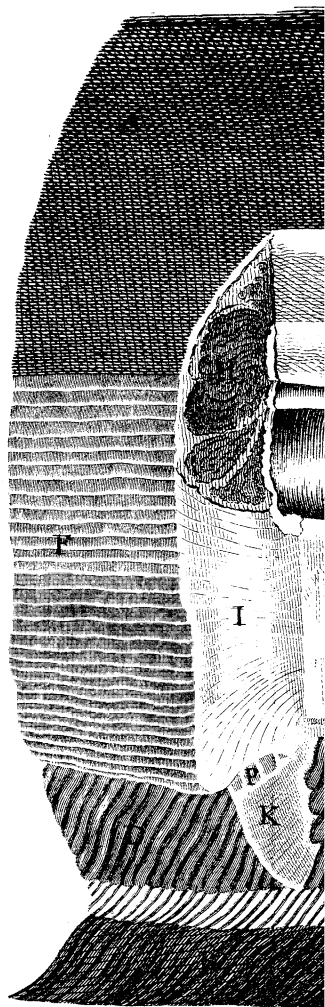
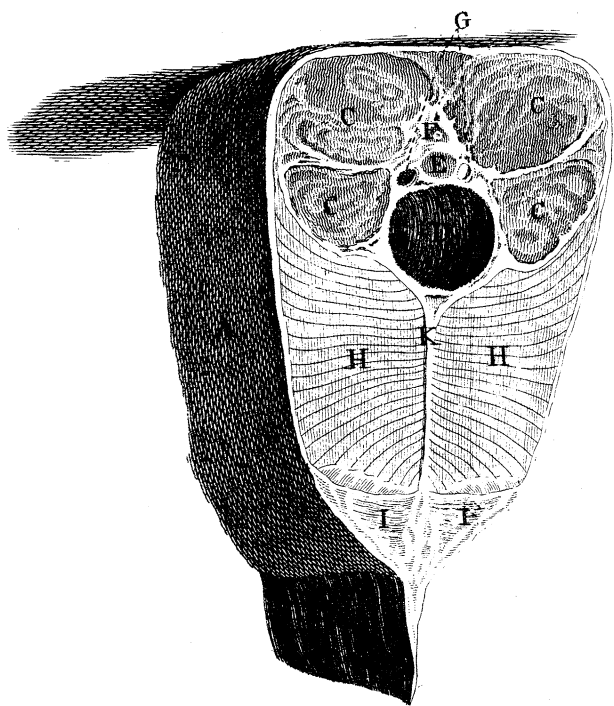


Fig 4

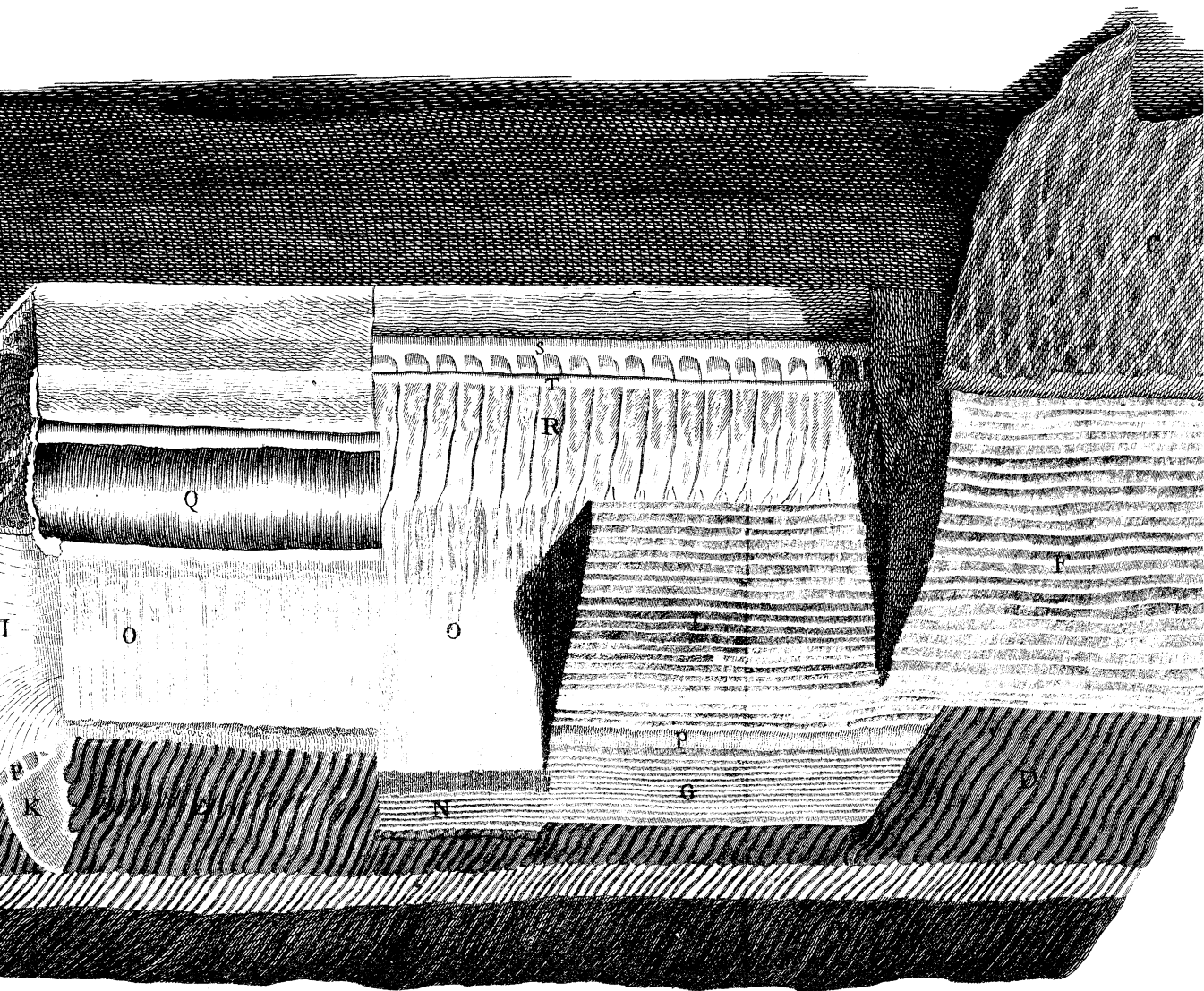
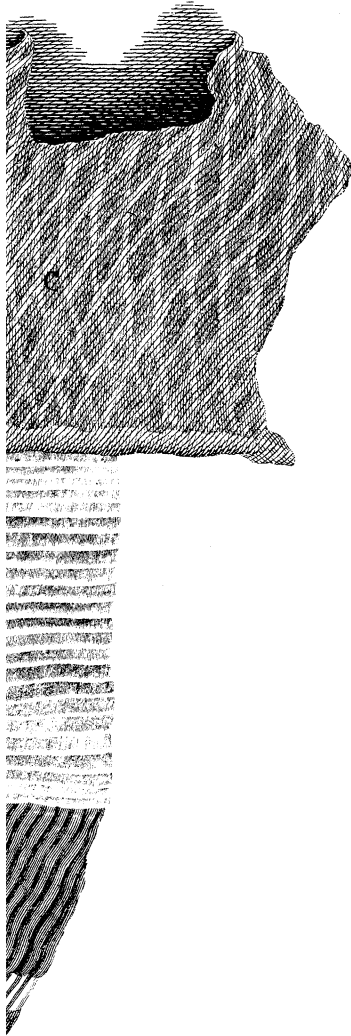


Plate 3



James Roberts delin et Sculp

Fig 1

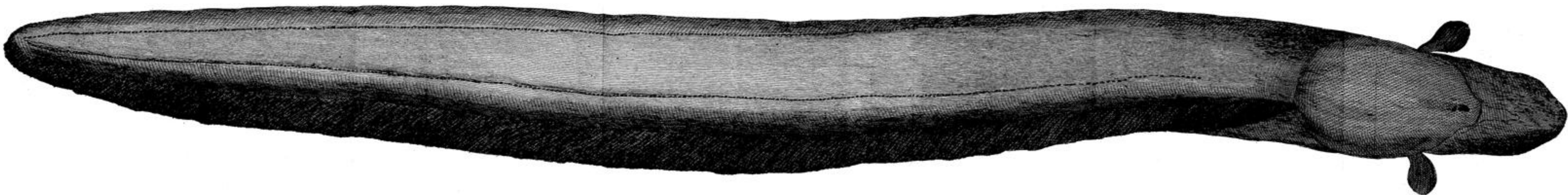
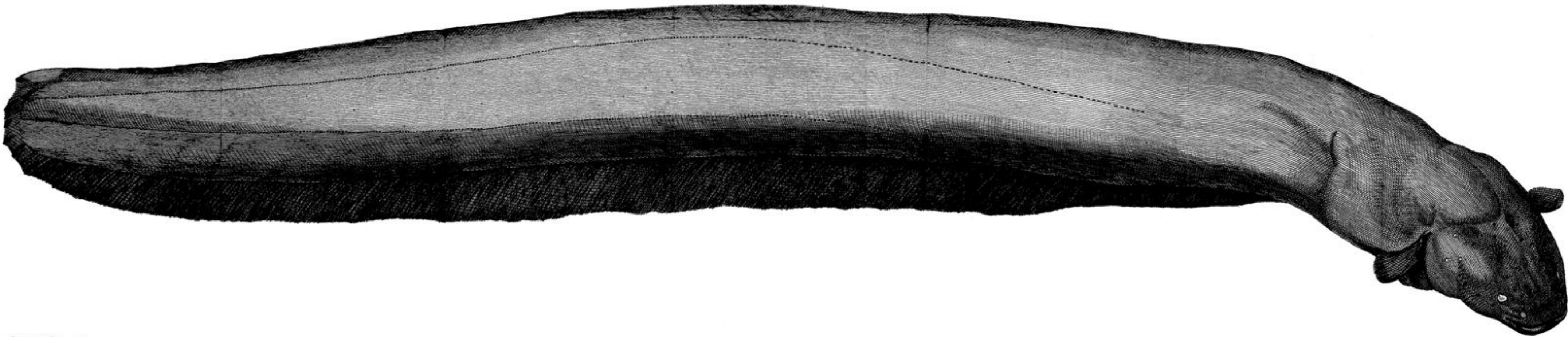


Fig 2



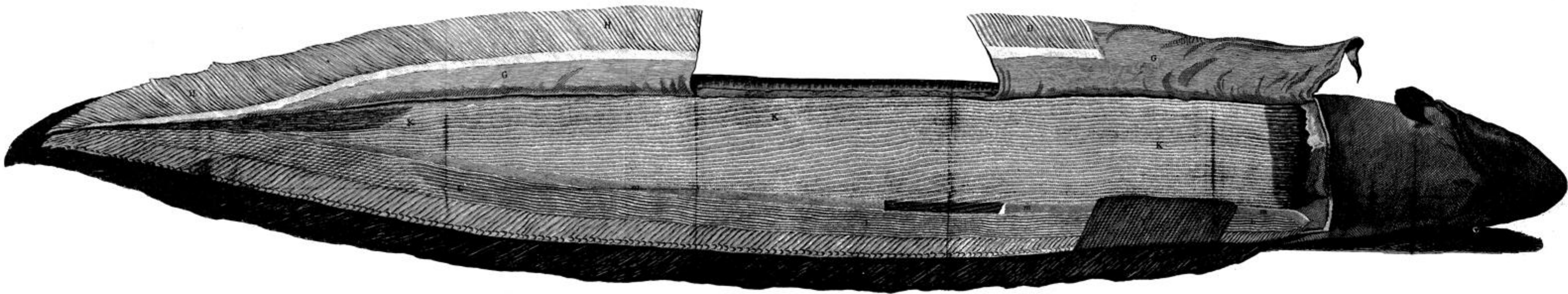


Fig 3

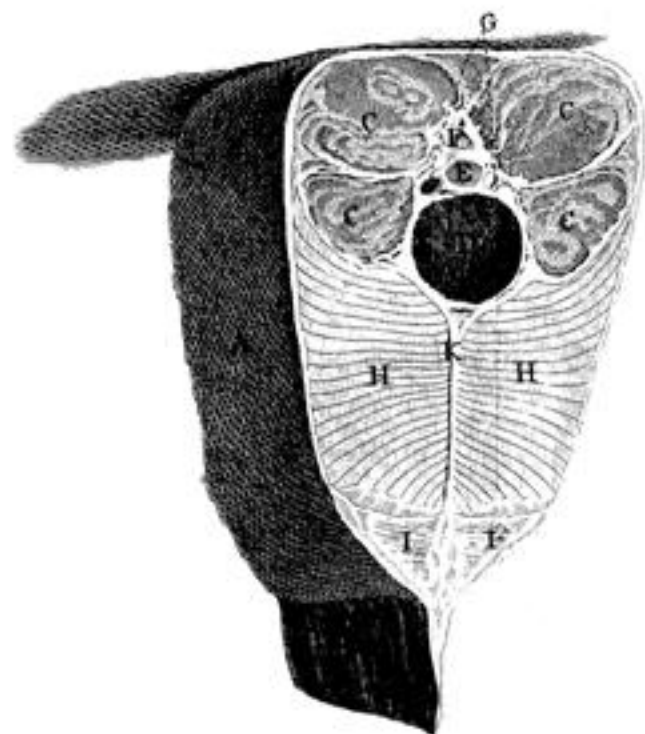


Fig 4

